Fermilab Simulations for Neutrinos Working Group
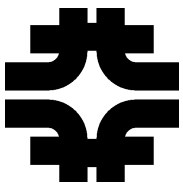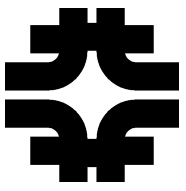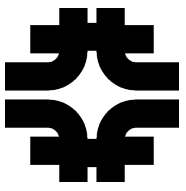
Gabriel N. Perdue

Fermilab

Goal of this Group

- No particular order:

  - Improve the software (code and physics).

  - Build expertise in the community.

  - Empower the experiments.

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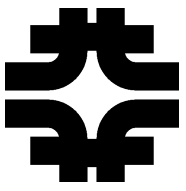Simulations for Neutrinos

Goal of this Meeting

- It will be difficult to come to conclusions on common priorities in the time we have.

- We should focus today on listening to everyone's goals and interests.

- Once we have heard from everyone we should use the time we have for discussion.

- I will produce a memo after this meeting summarizing and synthesizing the content and discussion.

- Between this meeting and the next we will refine the contents of that document and discuss its content by email. By the time we meet next month we may be ready to start work and at the very least should be in position to have a really thorough discussion of possible projects.

Major GENIE Efforts at FNAL

- Validation.

- New model implementation.

- Consulting & general support for laboratory experiments and the lab staff and user community.

  - Our interactions are mostly with the experimental community at the lab, but we would love to engage with theorists as well.
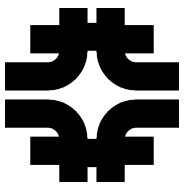
Major Geant Efforts at FNAL

- Physics Validation:

  - Routine validation of hadronic physics models.

  - Maintenance and development of Validation Framework.

  - Maintenance and development of Validation Repository (keep validation results including comparisons between Geant4 and data)

- Study and development of physics lists for use by the IF experiments.

  - Long term: model improvements.

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Major Geant Efforts at FNAL

- Improvements to Geant4, e.g. muon capture physics.

- Direct support of IF experiments.

- Consulting & general support for laboratory experiments and the lab staff and user community.

- Development of artG4tk: art + Geant4 framework and interface.

  - Package to monitor various aspects of Geant4 and prototyping experiments.
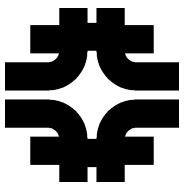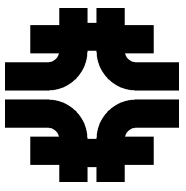
# Major Geant Efforts at FNAL

- Liquid Argon: study of physics performance of Geant4 in liquid Argon.

- Geant4 Profiling and Benchmarking.

  - CPU and memory profiling of Geant4 releases.

- Geant4 code reviews.

- New technology R&D (vectorized instruction set processors, GPUs, many-threaded applications, etc.).

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Integration with the Working Group

- We would like to offer expertise and targeted labor to help experiments overcome specific obstacles.

- This effort will be more successful if we can concentrate on a relatively small number of topics as a community here at the lab.

- Consulting and user support will always be available. If you have a small project or an emergency need that is not on the agenda of this group, we are always willing to consult and answer questions.

  - Example: Supernova neutrinos in NOvA.

- When it comes to significant investments of our time into major projects, we would like to organize those efforts through this group.
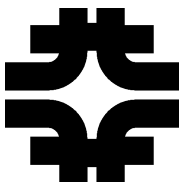
Our GENIE Goals

- C. Andreopoulos (GENIE spokesperson) articulated a clear purpose for GENIE validation:

    - Reduce cycle time.

- Cycle time is the time required to implement a one-line bug-fix and prove there were no unintended consequences anywhere in the software.

- **The GENIE collaboration takes total package integrity VERY seriously – the validation process is the gatekeeper to issue a release.**

- This is why the validation is important. **Fast, stable validation means a rapid release cycle becomes possible.**

- GENIE has a good validation framework for a HEP software project, but cycle time is currently ~2 months.

    - Our goal is one week.

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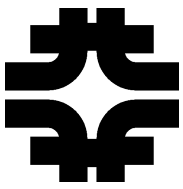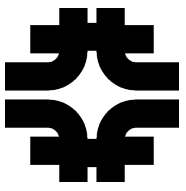
GENIE Validation

- Two components:

  - Validation applications: often specific to experimental results (to account for the different sets of uncertainties provided), but sometimes general. These programs compare predictions of the generator to data.

  - The validation framework: infrastructure to automate the production of MC samples and uncertainties, run the applications, store and summarize the results, present summary statistics and histograms. We would like to be able to run the validation weekly using an automated framework. It should present easily consumable summaries and detailed plot books for a thorough reference.

- The validation framework is a responsibility of the core GENIE group at Fermilab only — we don't expect any involvement with that part of the project from the user community.
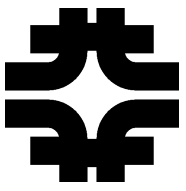
Why Work on GENIE Validation?

- For our partners in the experiments, "validation" means "applications that compare Monte Carlo to data."

- It makes sense to work on these applications inside GENIE as opposed to specific experimental software frameworks because it is easier for the whole community to benefit.

- We're adding nicer "analysis" tools (e.g., an experiment neutral version of Minerva's "PlotUtils" ROOT plotting and systematics analysis package) to enhance productivity.

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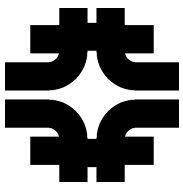
GENIE Validation Applications

- The current set is reasonably comprehensive but some pieces are missing:

  - Re-weighting (some pieces are available, but nothing coherent)

  - Flux driver

  - Geometry

  - Many recent "flagship" results (e.g., MiniBooNE double-differential QE results, MINERvA results, etc.) that are important to the community lack comparisons.

    - **This is where we would especially like to engage with the experimental community at Fermilab!**

- We aim to provide clear guidance to developers working on **new** features now — how do they build validation into the model they are working on now?

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Back-up

GENIE Validation Applications

- See this talk from C. Andreopoulos:

  - http://projects-docdb.fnal.gov/cgi-bin/ ShowDocument?docid=2927

- Current, active work at Fermilab:

  - J. Yarba on the hadronization package.

- There are many existing apps. Most are in good shape, but we will probably need to do some refactoring / rewriting in some cases.

- We need more though and would like to engage in partnerships with experiments to produce them.
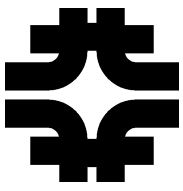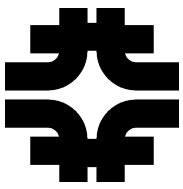
Why Work on GENIE Validation?

- Making the correct comparisons between MC and data is tricky:

  - Did you represent the experiment's acceptance correctly?

  - Did you interpret all the uncertainties correctly?

  - Did you use the correct flux? Was it important to use the specific experimental geometry?

- These are all problems which require physics judgement. Learning how to make these comparisons teaches important analysis skills and builds enormous familiarity with how to tune and use GENIE.
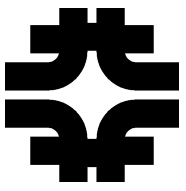
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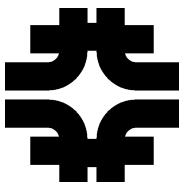
Why Work on GENIE Validation?

- Validation and tuning are not the same thing, but validation is a pre-requisite for tuning and a well-developed validation application makes tuning straightforward.

- For example – suppose your experiment has data that you can compare to a GENIE prediction. How do you quantify changes in the agreement when you add the new model you think you need?

  - If your validation app quantifies agreement, it is simple to compare.

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Why Work on GENIE Validation?

- Finally, every experiment should validate their local GENIE build. No matter how you got it!

- We've had problems in the past:

  - All NuMI experiments are dependent on the GENIE flux driver. If that develops problems, the GENIE validation team may not notice (it is a FNAL-specific component). NuMI Experiments have experienced this problem once already.

  - The GENIE team does not validate against all possible combinations of package dependencies. Minerva ran with a non-default PDF access (cernlib instead of LHAPDF) and had problems that were not encountered by GENIE people doing validation.

- An ounce of prevention is worth a pound of cure: we are often not serious about the idea until we've had problems at least once – let's change that.

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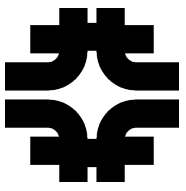
Lab Facilities for GENIE Validation

- We are attempting to secure dedicated computing resources for interactive development work at the lab.

- Additionally, this group will benefit enormously from the automated build and validation frameworks as they come on-line.

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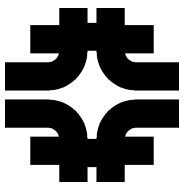
Current GENIE Validation Examples

- See:

  - https://users.hepforge.org/~candreop/outbox/genie/tuning/2012a/data_mc/latest/

- We would like to additionally compute chi-squared values and other statistical comparisons where appropriate.

- Another project is adding uncertainties to the MC prediction for "flagship" distributions using the re-weighting machinery.

How will this be tracked?

- We will report progress in presentations at Fermilab and to the appropriate GENIE working group.

- Locally, we plan on using Redmine.

- The initial plan will be to plan and divide responsibilities, connecting milestones with individuals using a Gantt chart.

- We will also use issue tracking on Redmine to organize new ideas as they occur and to report and handle bugs.

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